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TASK FORCE DELAY STUDY. DENVER STAPLETON INTERNATIONAL AIRPORT.(U)
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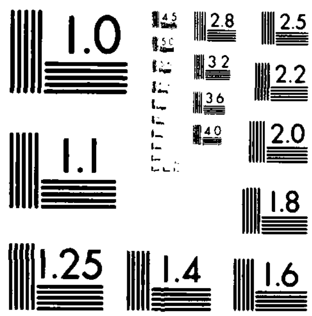

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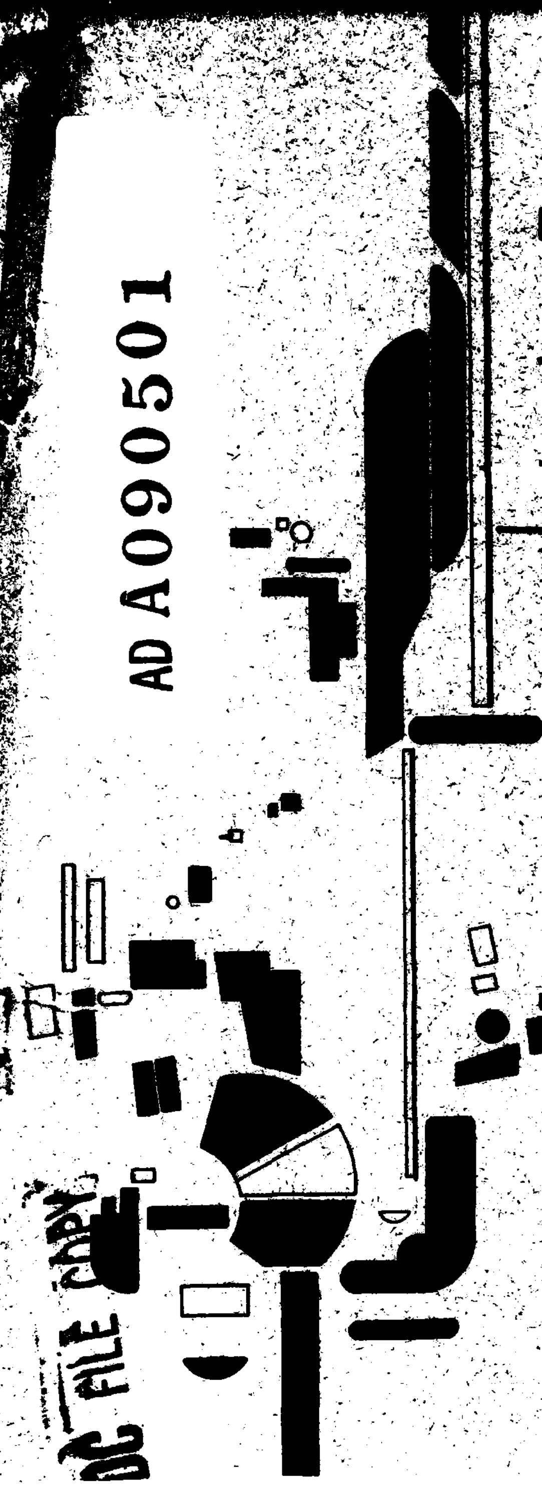

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Task Force Delay Study

Denver Stapleton International Airport
March 1980

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Supporting documentation can be found in the Task Force Delay Study, Denver Stapleton International Airport, Volume II.

16. Abstract

This report presents the results of a detailed analysis of the Denver Stapleton International Airport. The analysis was conducted by the Denver Airport Improvement Working Group which had representatives from the City and County of Denver, the Air Transport Association, the airlines serving Denver, and the Federal Aviation Administration. The purpose of the analysis was to determine the causes of delay and the potential delay reduction benefits of recommended improvements. The effort was part of the Airport Improvement Program.

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Preface

This study of air traffic delay at Stapleton International Airport, its causes, and potential solutions, has identified a comprehensive program of delay reduction measures which, if implemented, has the potential to dramatically reduce the level and costs of delay. The potential cost savings outlined are not intended to represent absolutes but rather *to point out the most productive* directions in which to focus action.

The study was conducted from 1976 through 1980 by a Task Force composed of representatives of the Federal Aviation Administration, the airlines serving Stapleton, the Air Transport Association and the City of Denver's Department of Aviation. The FAA provided the support of its Washington technical organization and consultant support from Peat, Marwick, Mitchell & Co.

The study has resulted in 14 specific recommendations for improvements for Stapleton International Airport. Task Force members plan to continue to meet as necessary to assist in the implementation of these recommendations and to provide a forum for the identification and assessment of further improvements.

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Introduction

Background

In recent years, runway capacity has steadily declined at the nation's airports. Noise restrictions and wake vortex separation standards, when coupled with increases in aviation demand, have resulted in significant increases in delay and delay-related fuel consumption.

The development of new metropolitan airports to augment system capacity and reduce delay is difficult and costly, as is the incremental expansion of existing facilities. It has become clear that to continue providing satisfactory air transportation service, the aviation industry must concentrate on achieving the highest efficiency of the existing airport system. To accomplish this and to identify future requirements in practical terms, quantitative performance data for major airports are needed. Such data would permit wise management decisions on (1) optimum airport use strategies; (2) expenditures for runways and other facilities and equipment; and (3) research and development priorities.

The establishment of a local Task Force was an outgrowth of Federal Aviation Administration (FAA) and Air Transport Association (ATA) concern about capacity and delay at the nation's major airports. A 1974 FAA report on airport capacity furnished considerable insights to capacity-related operational problems at eight of the country's major airports; however, it was decided that the findings should be evaluated by the persons directly involved in the operation and use of the airports. Therefore, in late 1974, the FAA established an ad hoc working group with the primary purpose of developing an action plan to reduce airport delays and to identify development options for implementation or further study at eight major airports. It was anticipated that recommendations developed jointly would form a basis of support for individual management decisions by each participating group. The net result of these joint recommendations was envisioned to be a coordinated series of further actions whose combined effect would be to reduce delay substantially.

Aircraft delays at Denver Stapleton International Airport have grown significantly over the past few years (13,900 hours in 1978). The Task Force formed to study congestion and delay at Stapleton included representatives of the Airport management, the Federal Aviation Administration, air carrier and general aviation interests, and the Air Transport Association.

Complementary studies are under way to prepare (1) an overall master plan outlining specific development needs on the Airport if it is to stay in operation through the year 2000, and (2) a feasibility and site selection study for a new metropolitan airport to serve Denver in the future, with transfer of operations to the new airport potentially taking place between 1990 and the year 2000.

The objectives, scope and methodology of the

Task Force study are summarized below. The key recommendations of the supporting technical studies are presented on the pages that follow.

Objectives

Considering Stapleton International Airport's escalating delays and their cost implications, the Task Force agreed on four objectives to guide the analysis of current and future operations. These objectives were:

1. To estimate current levels of Airport capacity and aircraft delay and to identify causes of delay associated with operations in the airspace, airfield, and apron/gate systems.
2. To estimate the potential benefits of reducing aircraft delay through alternative air traffic control procedures, Airport use policies, and facility developments.
3. To estimate current and future relationships between air traffic demand and aircraft delay as an aid for future planning.
4. To estimate the potential benefits of increased Airport capacity and reduced aircraft delay of proposed improvements in air traffic control systems resulting from the FAA Engineering and Development program.

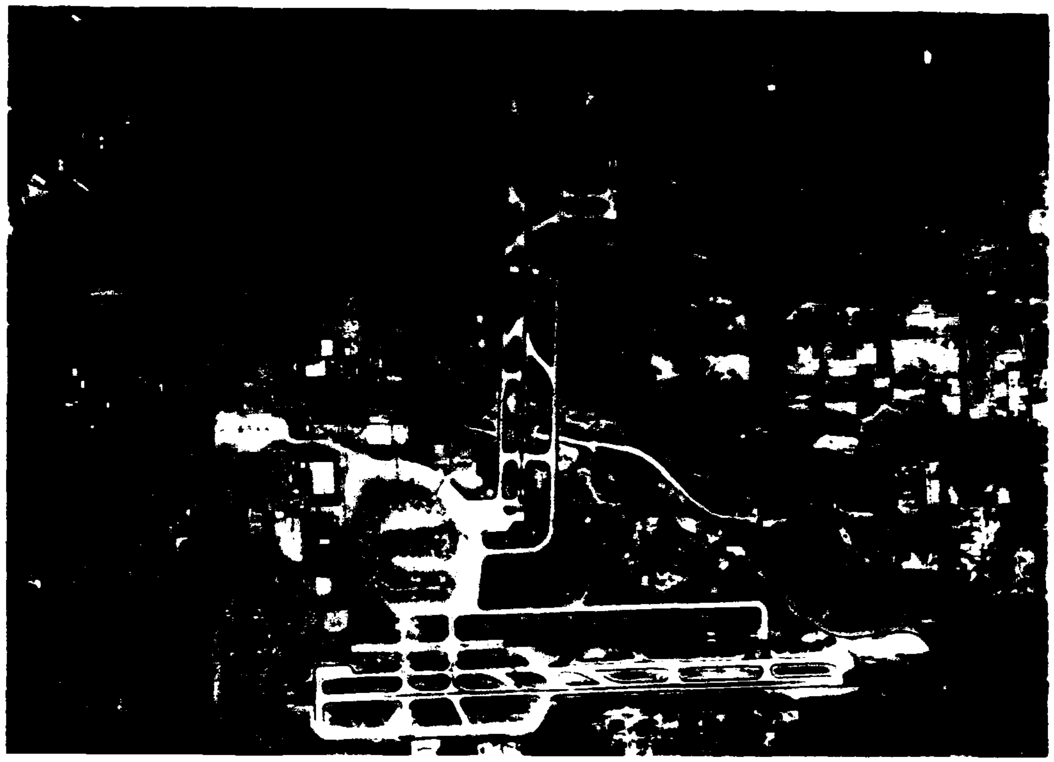
Scope

The analyses in this study focused on means of increasing the operating efficiency of the Airport and reducing aircraft delay through changes in air traffic control procedures, changes in Airport use policies, and (to a limited degree) potential airport development actions. Landside elements (such as the passenger terminal, concourse, and ground transportation access) were not examined because they are being addressed in the Airport master plan.

Environmental concerns were recognized in developing recommendations, but they were not within the scope of the Task Force study and are not addressed in this report.

Methodology

The study was conducted using a simulation model that reflects observed system operations. After the model was validated against real-world data on demand and delay, it was used to quantify the benefits of the delay reduction options identified by the Task Force. The data resulting from model experiments were then compared with data from control or baseline experiments, and the potential reductions in delay were assessed.



Recommended Improvements

The Task Force reviewed many different potential improvements in three general areas:

- Air traffic procedures
- Airport use policy
- Facility development

The review of these potential improvements—including the quantification of benefits, operational aspects, etc.—resulted in the selection of 14 specific recommended improvements. Brief descriptions of the improvements and estimates of their potential annual savings are shown in Exhibit 1. Details on the individual recommended improvements are given on subsequent pages.

Air Traffic Procedures

A1. Optimize Runway Preferential Use—Possible Savings, $1,000,000*

The most prevalent runway use in recent times has been for arrivals to use Runways 26L and 26R—with peak general aviation demand partially accommodated on Runway 25—and for departures to use Runway 35L and 35R. Although this configuration provides high capacity for short periods, it cannot sustain high demand levels because of associated taxiway congestion and close runway spacing. During periods of high arrival demand, the delay reduction benefits of triple arrival streams during Visual Flight Rule (VFR) weather conditions are significant. Through the use of Runways 17L, 17R, and 8L for arrivals and Runways 8L/R, and 7 for departures, triple VFR arrivals and departures are achieved. By using Runways 17, 17R for arrivals of high-performance aircraft and Runway 8L for low-performance aircraft, further efficiency is achieved. Turbojet and other high-performance aircraft can depart on Runway 8R, and small general aviation aircraft can depart on Runway 7—assuming the permanent designation of Taxiway 01 as Runway 7, 25. This configuration has a capacity of 150 to 160 operations per hour.

A2. Provide Converging ILS Approaches—*Possible Savings $1,500,000*

There is a need for dual approach streams when weather conditions are technically VFR, but not suitable for visual approaches. Dual approach streams can be achieved through Instrument Landing System (ILS) approaches to Runways 8L, 8R and 17L, 17R with savings of more than $1,000,000 per year. If innovative procedures for missed approaches can be developed, it appears that this procedure could be used in actual Instrument Flight Rule (IFR) conditions with total savings up to $1,500,000 or more.

A3. Minimize Constraints on Departure Airspace Procedures—Possible Savings, $1,900,000

The Denver Air Route Traffic Control Center requires departures using the same airway to be separated by a minimum of 5-miles-in-trail when they are handed off to the Center. To achieve this, departures must be delayed at takeoff. Several options are possible to reduce

these delays: (a) providing "radar vectors to on-course;" (b) allowing an interim separation standard on handoff (compromise between 3-mile terminal and 5-mile en route separation). These options could save about 1 minute of delay for half of the departures in 1985 for a savings of $1,300,000 per year. The prohibited airspace area P-26 also is a negative factor in delaying northbound turns of Runway 35 departures and extended downwind patterns on arrivals from the south. The estimated savings are $400,000 per year for arrivals and $200,000 for departures.

A4. Refine Arrival Metering—Possible Savings, $1,500,000
Metering software must be refined to allow the optimum benefit of profile descent. Aircraft and pilot capabilities must be better recognized and computer programs must be modified to better motivate pilot actions by requiring tight target times to checkpoints. Metering systems must provide for dual approach streams in VFR weather. Provision for breaking ties to parallel runways induces unnecessary delay. The metering rate must be optimized to better reflect proper allowances for pilot refusal of landings on Runway 26R and for pop-up aircraft not under en route positive control.

* Cost savings of the recommended improvements are not additive. Some recommended improvements attack the same problem area in a different way. Therefore, improvements must be judged in terms of overall costs and benefits. Costs are estimated on the basis of an average aircraft operating cost of $20 per minute. Therefore, a typical estimate would be as follows: When one minute of average delay can be eliminated for 250,000 aircraft operations, the savings will equal $20 multiplied by one minute multiplied by 250,000 or $5,000,000. Recent increases in aircraft operating costs make these values conservative.

Exhibit 1 Recommended Improvements

No.	Improvement	Potential annual savings
Air Traffic Procedures		
A1	Optimize runway preferential use	$1 million
A2	Provide converging ILS approaches Runways 17L or 17R and 8L or 8R	$1.5 million
A3	Minimize departure constraints	$1.9 million
A4	Refine arrival metering	$1.5 million
A5	Implement FAD* procedures	$1 million
A6	Provide independent IFR parallel approaches to Runways 17L/17R and 35L/35R)	
Airport Use Policy		
B1	Encourage use of satellite airports by low-performance aircraft	$3 million
B2	Control hourly demand (depeaking or quotas)	
B3	Schedule airfield maintenance to avoid peak periods	
Facility Development		
C1	Construct additional runway (independent IFR approaches)	$10 million
C2	Relieve bottleneck on south ramp (by threshold of Runway 8L)	$150,000
C3	Provide holding areas (avoid blocking taxiways)	
C4	Provide additional ground control frequencies	
C5	Improve runway surveillance (Airport Surface Detection Equipment, television, or new radar)	

* FAD Fuel Advisory Departure

A5. Implement FAD Procedures—Possible Savings, $1,000,000
When delay levels are high, or are expected to be high, aircraft should be issued expected runway arrival times prior to departing for Denver to allow maximum pilot discretion in decisions to minimize fuel use and/or use alternative destinations.

A6. Provide Independent IFR Parallel Approaches—Possible Savings, About 70% of the Cost of a New Runway
If changes in procedures and policies are possible, taking full advantage of runway threshold offsets, differential glide slope angles, maximum localizer divergence, etc., the massive capital cost of a new runway could be avoided.

Airport Use Policy

B1. Encourage Use of Satellite Airports—Possible Savings, $3,000,000
Segregation of low-performance aircraft is necessary to optimize Airport capability. As Airport complexity, delays, and costs increase—especially if private aircraft are charged costs that reflect their relative benefit from the Airport—those aircraft owners who can relocate to outlying airports will probably do so, and those who have a prime need to make connections with airline aircraft will remain.

If some combination of actions were taken which would reduce the impact of general aviation at Stapleton by 50%, savings would be about $3,000,000 per year.

B2. Control Hourly Demand
Future hourly demand must be controlled and maintained below the airfield capacity in VFR weather. Several options are possible: (a) quotas imposed by the airport sponsor and the FAA; (b) airline cooperation to spread scheduled flights more evenly throughout the day; and (c) limitations on terminal capacity to induce alternative actions by aircraft operators to reduce peak hour schedules. Such policy options can reduce delay significantly but must be developed in a total systems context recognizing economic and social impacts. National priorities for energy exploration and the Airport's role in expediting related actions demand that these options be approached with caution. (Illustrating the sensitivity of demand to delay in 1990, a 10% reduction in air carrier movements would reduce delay costs by approximately $10,000,000 a year.)

B3. Schedule Airfield Maintenance
Maintenance, except for emergencies, must be *scheduled during periods* of low demand—in most cases, at night. As congestion increases, critical attention must be given not only to the scheduling of construction to provide for maximum compression of the work, but also to balancing the choice of materials with the speed of construction (e.g., Portland cement versus flexible asphaltic pavement). Where material choices and construction scheduling have a significant delay effect, potential savings might be a matter of negotiation between the Airport sponsor and concerned airlines. The cost of closing Runways 8R, 26L during 1978 was estimated to range from $750,000 to $1,000,000 per month.

Facility Development Options

C1. Construct Additional Runway—Possible Savings, Over $10,000,000 Per Year After 1990
Even if short-term changes in air traffic control procedures can enable dual IFR approaches, the advent of high percentages of heavy aircraft in the future demands a parallel runway system with adequate separation for wake vortex protection. As future demand builds during all weather conditions, the need for triple independent VFR operations becomes more critical. The capability to handle large numbers of heavy aircraft is the most critical need for 1990 and beyond. For short-term needs, a shorter runway dedicated to slower, low-performance aircraft (air taxi, commuter, Convair 580s, etc.), as a first stage, can provide worthwhile reductions in delays.

C2. Relieve Bottleneck on South Ramp—Possible Savings, $150,000
By constructing taxiways to bypass the west ends of runways and by expanding and/or relocating existing taxiways, the present bottleneck can be relieved. Major improvement may not be possible without major relocations. Some improvements can be realized by more use of high-speed exits.

C3. Provide Holding Areas
At present, during certain times of high demand, the gate capacity of the Airport is exceeded. As a result, the line-up of aircraft backs up onto the active taxiway and, during severe periods of congestion, onto the active runways themselves. The construction of holding areas, or "penalty boxes" would provide some relief. The benefits would be a reduction in controller workload and the elimination of occasional back-up on active taxiways.

C4. Provide Additional Ground Control
At present, during several times of the day,

pressure of too many pilots trying to communicate with ground control results in severe frequency congestion and delay for the aircraft wanting to request clearance to taxi, etc. Following the lead of dual frequencies for approach and departure control, the time has come for additional frequencies devoted to ground control.

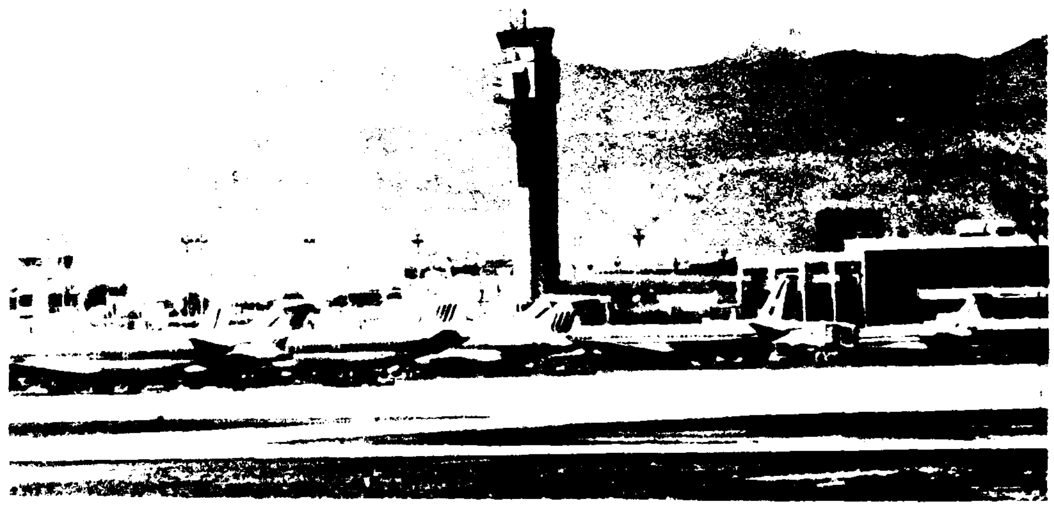
C5. Improve Runway Surveillance

Distances to the northern ends of Runway 35L, 35R are so far that aircraft position cannot be accurately determined from the tower. This condition becomes more critical during periods of snow, rain, and fog, and during extremely hot weather when visual refraction from heat reduces visibility. The main benefit of improved surveillance would be to assure that runways are clear of arriving aircraft when operations are to the north. Additional circulation benefits would accrue to the the entire Airport at night. Possible options: Airport Surface Detection Equipment (ASDE), television, new tower.

Note: Physical Improvements in Place

A number of physical improvements that were assessed during the first (capacity) phase of this study have already been implemented. These are: (1) for Runway 17L an instrument landing system, visual approach slope indicator, and runway end identifier lights; (2) a new exit Taxiway C-9 for Runway 8R; (3) a large fillet for Taxiway D at its intersection with Runway 26L; (4) added fillets for several exit taxiways from Runway 35R; (5) temporary designation of Taxiway 01 as Runway 7, 25; and (6) relocation of the Denver VORTAC* to the northwest quadrant of the airfield. Now under way, but not yet completed, are: (1) a localizer for Runway 8R; (2) extension of Taxiway D-3 from Taxiway D to Taxiway Z; (3) the addition of a new high-speed exit for Runway 17L; (4) a holding apron (penalty box) adjacent to the passenger terminal apron; (5) the extension of Taxiway D westward to the Concourse A apron; and (6) physical improvements to expand the aircraft basing capacity at Jefferson County and Arapahoe County Airports.

* VORTAC = colocated very high frequency omnidirectional radio range and tactical air navigation equipment facility



Summary of Technical Studies

The operation of the existing airfield and the potential benefits of the improvements were assessed in terms of airfield capacity, airfield demand, and average aircraft delays. Estimates of average aircraft delays are based on the values—and the interrelationships—of airfield capacity and demand. The estimated average aircraft delays permit assessment of both the operational fcasibility of the airfield and the potential economic benefits of improvements.

Various airfield system improvements, ranging from changes in air traffic control procedures to changes in physical facilities and operations can increase airfield capacity and thus reduce delays. If a dollar value is attached to each minute of average aircraft delay, the cost of a particular airfield improvement can be weighed against its annual delay savings. Thus, a comparison of the costs and the delay reduction associated with each of the various improvements indicates which are the most effective. For a given forecast increase in demand, a suitable combination of airfield improvements can be implemented in stages so that airfield capacity is increased as needed and average aircraft delays are maintained within acceptable limits.

The following paragraphs summarize the technical studies. First, present-day operations at the Airport are briefly described. Then, estimates of present and projected airfield demand, airfield capacity, and average aircraft delay are presented. Next, the airfield capacity increases and the aircraft delay reductions associated with the recommended improvements are illustrated. Finally, the

Exhibit 2 Airfield Operations

Weather	Visibility / ceiling	Percentage occurrence
VFR1	Better than 3 miles / 2,100 feet	90.0%
VFR2	Less than 3 miles / 2,100 feet but better than 3 miles / 1,000 feet	4.6
IFR1	Between 2 miles / 800 feet and 3 miles / 1,000 feet	.4
IFR2	Operating minimums	4.0

interrelationship of airfield demand, airfield capacity, and aircraft delays is examined.

Runway Configurations

Exhibit 2 illustrates the runway configurations use at the airport and presents the average percentage utilization of these configurations in different weather conditions.

Exhibit 2 Airfield Operations (continued)

		Percentage use (1978 Baseline)				
Runway Use	Configuration	VFR1	VFR2	IFR1	IFR2	Total all weather
1		49.1%	3.1%	0.9%	2.9%	56.0%
2		1.1	0.1	0.1	0.4	1.7
3		31.3	1.0	0.2	0.5	33.0
4		2.0	0.0	0.0	0.0	2.0
5		2.7	0.3	0.2	0.2	3.4
6		3.8	0.0	0.0	0.0	3.8
7		0.0	0.1	0.0	0.0	0.1
Total		**90.0%**	**4.6%**	**1.4%**	**4.0%**	**100.0%**

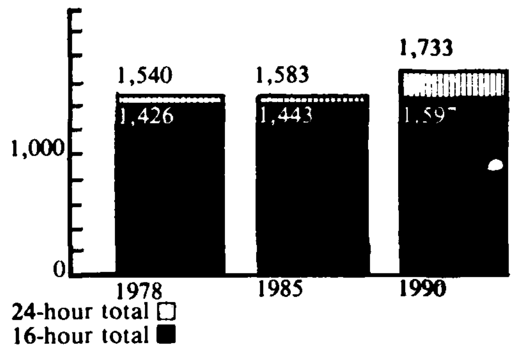
Arrival
Departure

Airfield Demand

Exhibit 3 illustrates projected increases in annual demand from 466,645 aircraft operations (landings and takeoffs) in 1978 to 575,650 in 1990, and corresponding increases in daily peak hour traffic.

Exhibit 3 Airfield Demand Levels

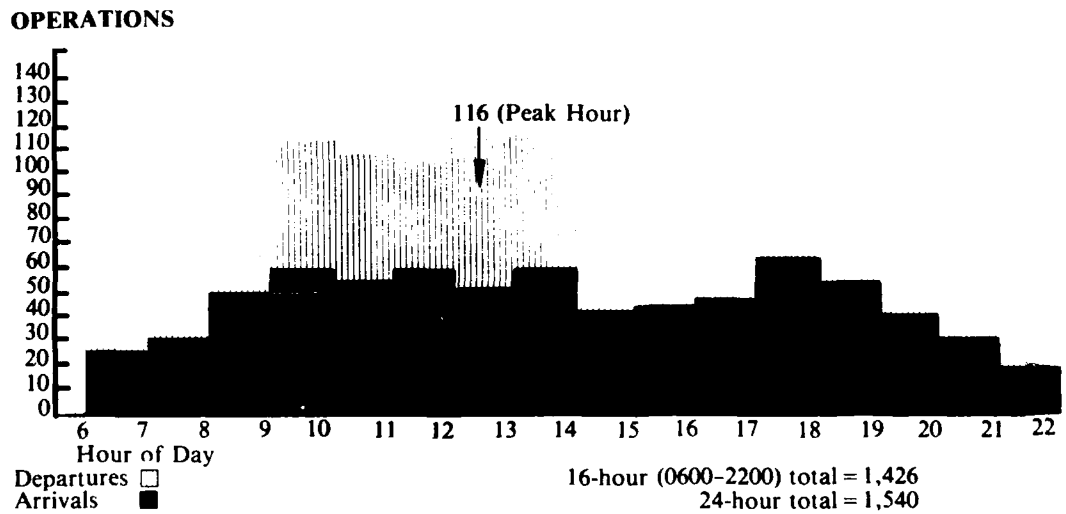
Average Day, Peak Month Demand



Aircraft operations

	Annual	24-hour day (average day, peak month)	Peak hour
1978	466,645	1,540	116
1985	524,270	1,583	120
1990	575,650	1,733	130

Hourly Variation of 1978 Demand (Average Day, Peak Month)



Airfield Capacity

Airfield capacity is the maximum number of aircraft operations (landings or takeoffs) that can be processed in a given time under specific conditions of:

- Airspace constraints
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix (types of aircraft)
- Percent arrivals

Airfield capacity is normally expressed on an hourly basis.

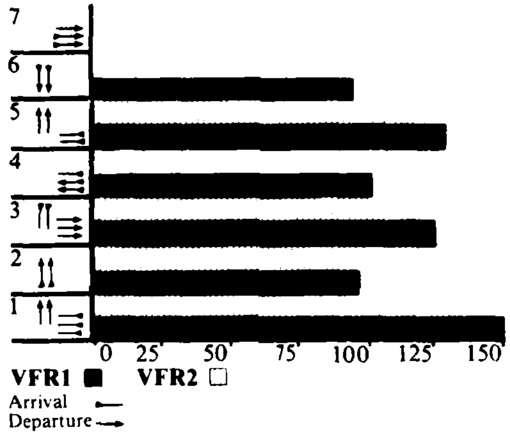
Many factors limit airfield and airspace capacity at Stapleton, including:

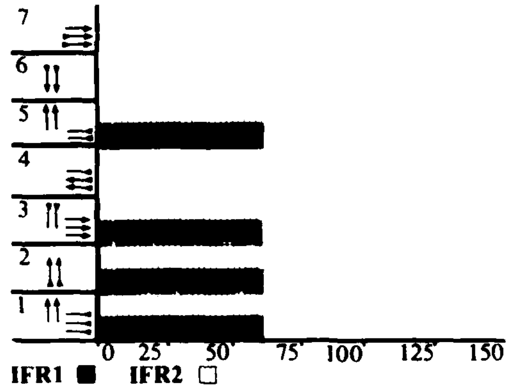
- Proximity of parallel runway sets (ILS approaches to parallel runways are not independent)
- Weather, wind, and visibility limitations (Weather anomalies cause frequent changes in runway use and often limit *approach to one direction)*
- Wake turbulence and the mix of heavy aircraft (Heavy aircraft mix: 8% in 1978, projected to 12% in 1985, 16% in 1990, and 40% in the year 2000)
- Requirement *for en* route separation (Aircraft must be spaced 5 miles apart when Air Route Traffic Control Center assumes control. This requirement causes takeoff delays)
- Hot weather and high altitude effects (Departures on Runways 17L, 35R are increased on hot days)
- Pilot preference for Runway 8L, 26R
- Metering inefficiency
- Airfield maintenance and construction
- Lack of aircraft holding area
- Runway and apron congestion
- Restricted Airspace Area P-26
- Placement of general aviation areas
- Effect of Stapleton operations on neighboring airports

Exhibit 4 shows estimates of airfield capacity for the runway configuration and weather conditions defined in Exhibit 3.

Exhibit 4 Airfield Capacity

1978 Baseline Capacity (Operations Per Hour)





Airfield Delays

Airfield delay is the additional travel time, caused by airfield congestion, taken by an aircraft to move from point A to point B. Computing average annual airfield delays involves:

- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics
- Airfield demand
- Weather

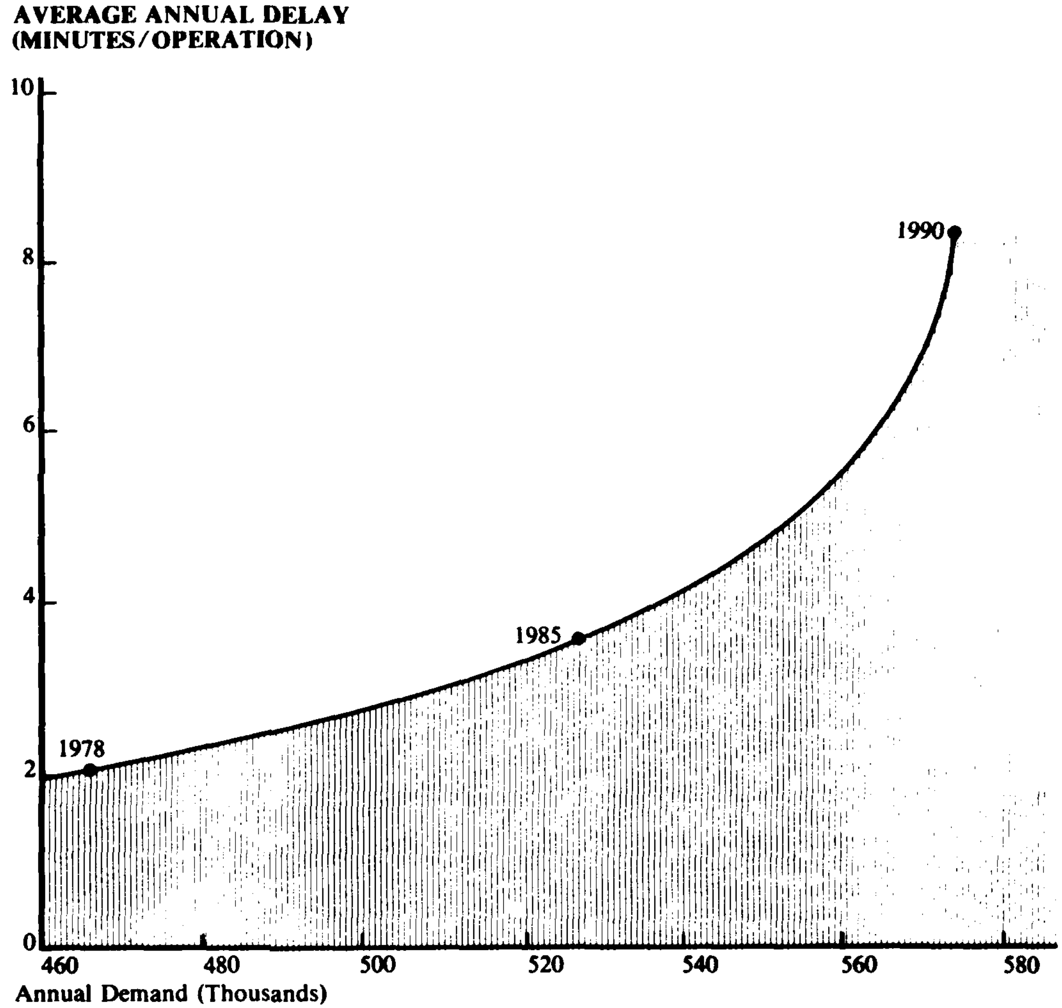
Average annual delays are expressed in minutes per aircraft operation.

Congestion results whenever the volume of aircraft operations at an airport approaches airfield capacity. Aircraft delays during congested periods are very high; and consequently the average aircraft annual delays are also high. High levels of congestion will prevail at Stapleton International Airport by 1990 unless airfield improvements and/or changes in air traffic control procedures are implemented to increase its capacity.

Exhibit 5 illustrates the increases in average annual delay that are estimated to occur in the future if no improvements are implemented.* If the improvements identified in Exhibit 1 are implemented, average annual delays would be significantly less than those identified in Exhibit 5, and annual delay cost savings of $20 million or more could be achieved.

* Note that average annual delays are estimated to be just under 4 minutes per aircraft in 1985. Corresponding peak hour delays would be much higher, ranging up to 15 minutes in VFR and 60 minutes in IFR.

Exhibit 5 Estimated Annual Delay 1977-1990 (Do Nothing Situation)



Estimated Delay Savings

E&D improvement	Minutes per aircraft	Minutes per year	Costs per year at $20/minute
Near-term systems (1985)	0.5	262,000	$ 5,200,000
Far-term systems (1990)	2.8	1,612,000	$32,200,000

Impact of FAA Engineering and Development Programs

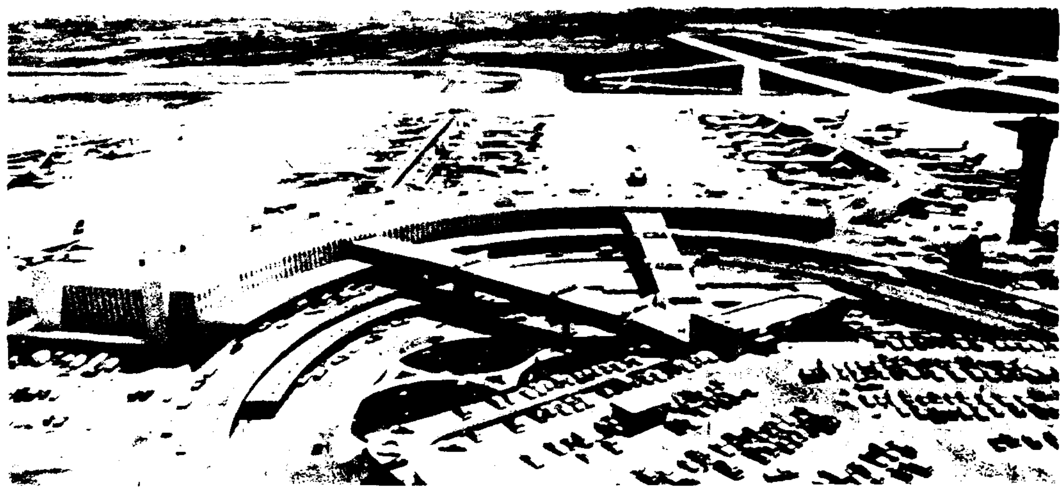
The Task Force also attempted to estimate the potential delay savings associated with FAA Engineering & Development (E&D) programs.

For purposes of analysis, the impact of the programs was identified by the FAA as being "near term" and "far term" according to the estimated time of availability. The "near term" programs were assumed to be operational at Stapleton in 1985; the "far term" in 1990.

For study purposes, the Task Force used the air traffic control operating parameters of these programs as given in the FAA report, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay" (FAA-EM-78-8A), dated June 1978. Accordingly, the standard minimum IFR arrival/arrival separations were reduced from 3 nautical miles (nm) today and in the near-term, to 2nm in the far-term. The largest minimum arrival/arrival separation, e.g., for a small aircraft operating behind a heavy aircraft, was reduced from 6nm today to 4nm in the near-term and to 3nm in the far-term. The minimum departure/departure separation, which today ranges from 1 to 2 minutes, was not changed in the near-term but was reduced to 1 minute for all departure combinations in the far-term.

The evaluation is based on output from a computer model which produced average annual delay in minutes per aircraft movement in 1985 and 1990. Two cases were studied: (1) a base case with no improvements, and (2) a case in which the E&D systems were operating and **wake vortices were assumed absent all year.**

In view of these results, the Task Force strongly supports the expeditious development of these systems.



Action Plan

No.	Improvement	Time frame: Short-range	Time frame: Intermediate range	Lead agency: FAA	Lead agency: Airlines	Lead agency: City
	Air Traffic Procedures					
A1	Optimize runway preferential use	●		●		●
A2	Provide converging ILS approaches	●	●	●		
A3	Minimize constraints on departure airspace procedures	●		●		
A4	Refine arrival metering	●	●	●		
A5	Issue expected arrival times		●	●		
A6	Provide independent IFR parallel approaches (Instrument Landing System to Runways 17L/17R and 35L/35R)	●		●		

Action Plan (Continued)

No.	Improvement	Time frame: Short-range	Time frame: Intermediate range	Lead agency: FAA	Lead agency: Airlines	Lead agency: City
Airport Use Policy						
B1	Encourage use of satellite airports by low-performance aircraft		●	●	●	●
B2	Control hourly demand (depeaking or quotas)	●		●	●	●
B3	Schedule airfield maintenance to avoid peak periods	●				●
Facility Development						
C1	Construct additional runway (independent IFR approaches)		●			●
C2	Relieve bottleneck on south ramp (by threshold of Runway 8L)	●	●			●
C3	Provide holding areas (avoid blocking taxiways)	●				●
C4	Provide additional ground control frequencies	●		●		
C5	Improve runway surveillance (Airport Surface Detection Equipment, television, or new radar)		●	●		

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